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the Danish State at Copenhagen. The pendulum had a length of 17 meters, and weighed 35 kilogrammes. After an hour had elapsed the pendulum had just passed the twelfth degree of the circle accordant to the calculated deviation.

VISUAL OBSERVATIONS OF THE MOON AND PLANETS, MADE AT HARVARD COLLEGE OBSERVATORY.*

BY EDWARD S. HOLDEN.

The volumes of the Harvard Observatory *Annals* are printed with a commendable promptness that adds greatly to their usefulness. Most of them deal with technical matters of no great immediate general interest. The two volumes noticed contain several chapters, however, on the changes observed in the surface of the Moon, on the planets, etc., that are especially interesting to all intelligent people, and for this reason, it is here attempted to give some account of their contents. As many of the results attained are novel, it is, first of all, sought to present them with sufficient fullness. This is not the place for a discussion as to the evidence upon which they rest.

Volume XXXII of the *Annals* contains a chapter upon the surface conditions and the rotation of the planet *Mercury*, the diameter and atmosphere of *Venus*, and the surfaces of *Jupiter*, *Saturn*, *Uranus*, and *Neptune*. The discussion of the observations of *Mars* is reserved for another volume. The observations of *Mercury* are illustrated by sixteen sketches by two observers (W. H. PICKERING and DOUGLAS) of the excessively faint surface markings. Mr. PICKERING's conclusions from these drawings are that no rotation of the markings was noticeable between July 14, and August 5, 1892, a period of twenty-two days, or one quarter of the period of revolution of the planet in its orbit, and that the period of rotation of the planet on its axis and revolution in its orbit must coincide, as was announced by SCHIAPARELLI in 1879. It is, in fact, not unlikely that the two

* *Annals of the Astronomical Observatory of Harvard College.* EDWARD C. PICKERING, Director. Vol. XXXII, Part II. Visual Observations of the Moon and Planets, by WILLIAM H. PICKERING, Assistant Professor of Astronomy in the Observatory, Cambridge, 1900, 4to, and *ibid.* Vol. XXXIII. Miscellaneous researches made during the years 1894-99. Cambridge, 1900, 4to.

periods do coincide, but the observations here given present little evidence to prove it. The drawings of the two observers, P. and D., differ on July 22d at 8^h, agree very well at 10^h, differ widely on July 23d at 6^h, agree fairly on July 23d at 9^h. But the drawings last mentioned should agree with the pair made at 10^h of the day previous to prove the point at issue, whereas there is little, if any, resemblance; and there is no agreement at all in the extremes of the series July 14th and August 5th. The observations in question are excessively difficult to make, but those that have been secured are not, it would seem, adequate. Mr. PICKERING concludes that the atmosphere of this planet is very rare, and that the hemisphere turned towards the Sun is very likely incandescent, while the temperature of the central regions of its opposite hemisphere is much lower than that of our Arctic regions. A curious distribution of matter would thus take place on the surface, through a process of fractional distillation. The hemisphere that is perpetually illuminated by the Sun would be composed of substances of high boiling points, while the other hemisphere would be composed only of those of very low boiling points. It is not likely, we may add, that a planet subject to such conditions can sustain human life.

The diameter of the planet *Venus* was determined to be 7,662 miles. In its size, as well as in certain other respects, it is not unlike our Earth. Measures of the horizontal refraction of the atmosphere of *Venus* give 93', which is much greater than previous results. If, as is probable, the surface of *Venus* seen by us, is no more than the outer layers of its clouds, it follows that at the planet's real surface its atmosphere is many times denser than our own. We may add here, that there is no proof that *Venus* is unfit for human habitation.

"The most important discovery relating to *Jupiter*," Mr. PICKERING says, "was in regard to the nature of the material forming its belts. As had been previously surmised, they were found to lie above the white, dense, cloudy surface of the planet; but what was perhaps unexpected, was the fact that the appearance was not due to large dense masses of cloud, but to numerous very minute, isolated cloudlets." A very good photograph of *Jupiter*, and an excellent photograph of *Saturn*, are reproduced in the plates.

The diameter of the planet *Neptune* was determined to be 31,000 miles, and its disk was found to be decidedly darker at the

edge than at the center, thus proving the existence of a deep atmosphere. *Jupiter, Saturn, Uranus, and Neptune* are, it may be added, alike in this respect. All of them have extensive atmospheres, but little is known of the constitution of their envelopes, and next to nothing of the condition of their solid or liquid nuclei. It is likely that all of them are at a high temperature.

SWIFT'S comet of 1892 was the subject of investigation by photography and otherwise. Some of the photographs are reproduced in the volume, and they are extremely interesting. Those of the inner portions of the tail seem to show that the comet was rotating on an axis passing longitudinally from the head through the tail in a period of about four days. Mr. PICKERING points out that there is an *a priori* reason for such a rotation. "In the light of the connection between sun-spots and terrestrial electric disturbances, it may be assumed that the Sun can be looked upon as an enormous electro-magnet, surrounded by an equatorial electric current. If now, the tail of a comet is due to electrically charged gaseous matter receding from the nucleus, we shall have a series of electric currents radiating from the nucleus like spokes upon the hub of a wheel, and bending backwards to form the tail. If the Sun and comet are electrified, as we have supposed, the jets and envelopes of the comet, carrying with them the tail, must rotate as we have described."

As the earth has a gaseous envelope, like a comet, and as it is subject to electric action from the Sun, the question arises whether something analogous to a comet's tail is not to be found on the Earth. Mr. PICKERING finds the analogy in the high auroras. "All the observations of high auroras are located along a line such as would be cut upon the surface of the Earth by a cylindrical tail 7,200 miles in diameter, whose axis passed through the center of the Earth and pointed directly away from the Sun." In diameter, length, direction, and time of formation, the aurora is shown to resemble the tail of a comet, and it appears likely that the secular auroral period has its analogue in the world of comets. Mr. PICKERING'S prediction is, that if a comet comes in view of the Earth during a year of great sun-spot activity, it is more likely to have a large and fine tail than if it arrives during a year of slight activity. Such a theory as this might, it would seem, be tested by the appearances of ENCKE'S periodic comet.

The following paragraph is quoted as a brief explanation of the phenomena of comets expressed in a simple form :—

“The head of a comet seems therefore to be merely a meteor-swarm containing so much gaseous material that when electrified by its approach to the Sun, it will be rendered luminous. When the gases, by successive discharge and loss into space, have become too rare to be rendered visible in this manner, the object, if discovered, is known simply as a meteor-swarm. Each meteor in the comet’s head, when remote from the Sun, is surrounded by its own individual atmosphere of hydrocarbons, etc., in a solid condition. When this atmosphere is sufficiently warmed by the Sun’s rays to evaporate, it becomes sufficiently electrified to partially overcome the slight force of gravity of the meteors, and a portion of it escapes and unites with that of other meteors to form the tail. Thus, if the meteors and their atmospheres are sufficiently widely separated from each other, the comet may be brilliant and yet transparent at the same time.”

No space remains to speak in detail of other interesting researches in these volumes. Long-continued observations on the Moon prove the existence of changes on its surface, of vegetation, of a slight atmosphere, according to Mr. PICKERING. As many of his conclusions are in the nature of discoveries, they will not pass unchallenged, and it is not difficult to point out paragraphs where more evidence is very desirable. At the same time, it is only just to say that the treatment of all the topics in the volume is suggestive, and thus very valuable, though it is often inconclusive, being based on too slight and easily accepted foundations. Volume XXXIII is devoted to miscellaneous researches on the brightness of certain asteroids, on the Gegenschein and Zodiacal Light (by Professor SEARLE), on Variable Stars, Nebulæ, Comets, Satellites, etc. Taken together, the volumes contain results of long-continued and faithful work, intelligently directed.

THE CHABOT OBSERVATORY-DOLBEER ECLIPSE EXPEDITION, MAY 28, 1900.

BY CHARLES BURCKHALTER.

The preparations for the expedition from this Observatory to observe the eclipse of May 28th next, at the expense of one of our members,—Mr. JOHN DOLBEER, of San Francisco,—are nearly completed. The Pierson eclipse telescope, with the Pardee lens attached, making two telescopes of four-inch aperture and fifteen feet focal length, is ready for shipment, and will be forwarded in a few days, to insure arrival in ample time.